CASE REPORT

The Use of the Robotic Arm-Assisted System (MAKO) for Hip Revision Surgery

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Abstract

The robotic arm-assisted system (MAKO) has pioneered a transformative approach to hip joint restoration, excelling in reinstating innate hip joint anatomy and biomechanics. This case represents the initial application of the system in revision surgery following a cut-out complication. A 69-year-old female, previously independent and mobile, presented with left hip pain. X-rays revealed a cut-out complication of the proximal nail, necessitating revision to total hip arthroplasty due to the patient's prior activity level and implant prominence. Utilizing the robotic system, preoperative planning accurately identified limb length discrepancy and guided implant sizing. The system facilitated precise acetabular reaming and optimal component placement. The patient regained functional independence. This report also underscores the system's potential for accurate acetabulum component placement and restoration of hip joint anatomy and biomechanics in revision cases. Future advancements in this technology may expand its role in complex reconstructions and revisions, further enhancing patient outcomes in hip arthroplasty.

Level of evidence: V

Keywords: Hip biomechanics, Hip joint anatomy, MAKO, Revision hip, Robotics, Total hip arthroplasty

Introduction

P Advances in total hip replacement have been revolutionary, offering accuracy, durability, and customizability tailored to individual patient's anatomy and biomechanics.[1] Innovations, including computer-guided navigation and robotic-assisted surgery, have transformed surgical precision, enabling meticulous planning and execution.[2,3] Implant materials have evolved substantially, integrating robust, long-lasting substances like ceramics and highly resilient polyethylene, ensuring extended implant longevity.[1] Less invasive techniques have emerged, reducing patient trauma blood loss and expediting recovery periods.[3,4] Patient-specific strategies, aided by advanced imaging and 3D modeling, have allowed precise implant sizing and placement, optimizing outcomes and reinstating natural joint anatomy.[2,4]

The robotic arm-assisted system (MAKO) initiated a groundbreaking transformation in hip joint restoration through its precision and customized surgical planning. At its core, this system excels in reinstating the hip joint's innate anatomy and biomechanics.[5] Before the procedure, the patient's anatomy undergoes meticulous mapping using advanced imaging methods, generating a 3D model that assists the surgeon in planning the surgery with exceptional precision. During the operation, the surgeon employs the robotic arm, guided by this comprehensive plan, to perform the procedure with remarkable accuracy, ensuring optimal positioning and alignment of the hip implant components.[2,4] This precision results in restoring the hip joint's natural biomechanics, enhancing stability, increased range of motion, and prolonged implant durability. The system's capability to replicate the patient's distinct anatomy and customize the procedure significantly contributes to faster recovery times and superior overall outcomes.[2,4-6]

The present report represents the initial attempt to use the system in a revision case due to a cut-out complication following the proximal nailing of an intertrochanteric hip fracture.

Case Presentation

A 69-year-old female presented to the outpatient clinic due

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to left hip pain and inability to bear weight starting three days ago. She was treated with a proximal intramedullary nail for a left peri-trochanteric hip fracture four months ago. Following the initial surgery, she began to mobilize with a walker and bear weight for the last three months. She complained that she always experienced moderate pain in the left hip joint after the initial surgery, but three days now, she could not put any weight on the left limb. Her remaining medical history was remarkable for diabetes mellitus and hypertension. It is of note that before the peri-trochanteric hip fracture, she lived independently and could walk for her everyday activities.

X-ray views revealed that the patient had suffered a cut-out complication of the proximal nail. The decision to revise it into a total hip arthroplasty was taken since the patient was active before the fracture, and the lag screw was prominent in the hip joint. We opted to utilize the robotic arm-assisted system for this patient to guarantee optimal implant placement and prevent future adjustments while ensuring no discrepancy in limb length.

Before the procedure, CT scans of the pelvis and both knees were performed [Figure 1]. These scans yielded anatomical details transferred into the preoperative workstation for evaluation, enabling virtual planning and execution. The MAKO® robotic arm-assisted system leverages this CT data to craft tailored preoperative plans, facilitating the selection of appropriate component sizes and ensuring accurate positioning of the stem and cup during the surgery. Moreover, the 3D models derived from the pelvic and knee scans provide valuable insights into the natural anatomy, encompassing pelvic tilt, leg length, and hip offset [Figure 2].

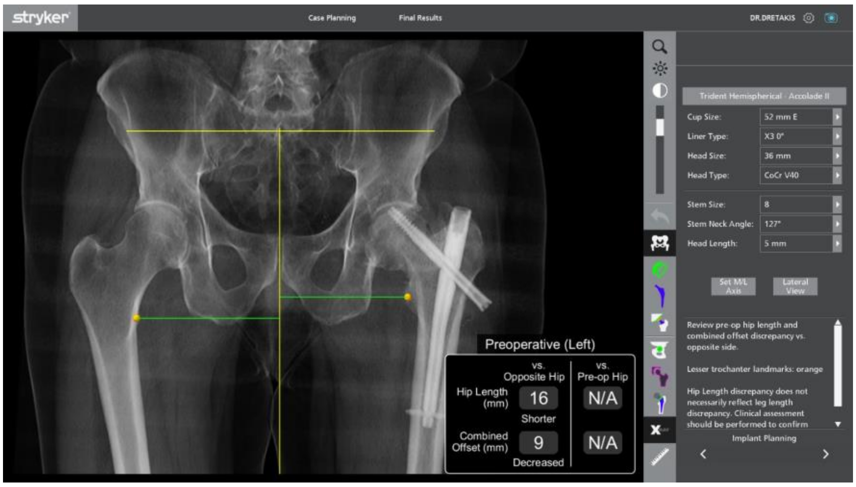

Figure 1. Anatomical information from the robotic arm-assisted system. The patient suffered from a leg length discrepancy of 16mm, while the combined hip offset was decreased by 9mm

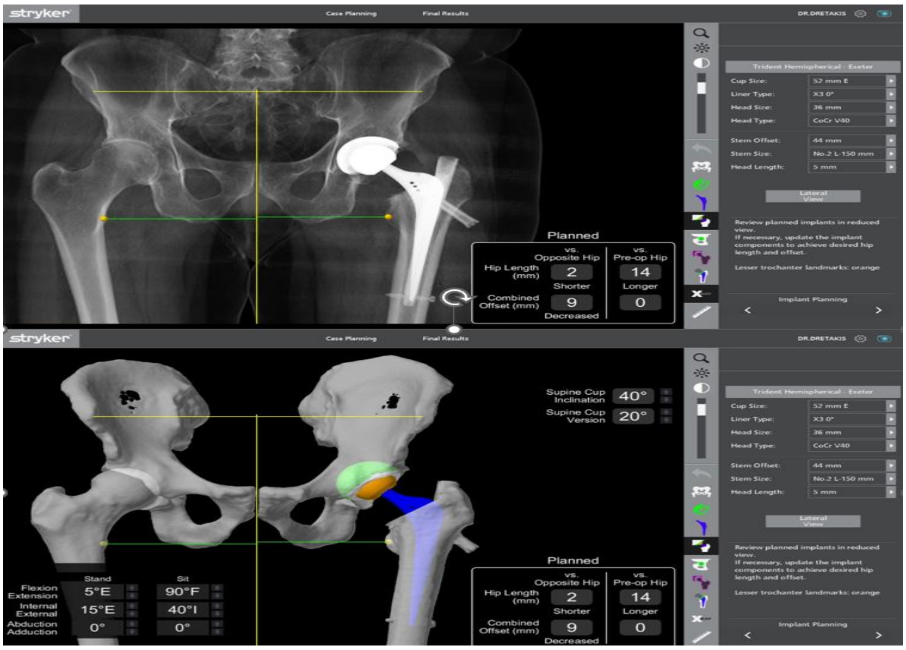

Figure 2. Preoperative surgical plan of the prostheses, sizing, and orientation

Before the surgery, it was discovered through preoperative planning that the patient had a limb shortened by 16 mm due to the cut-out complication. Factoring in the patient's anatomy, the acetabulum component (Trident Hemispherical cup, Stryker, Warsaw, Indiana, USA) was adjusted to 52mm, while the femoral stem size was determined to be 2 (Exeter, Stryker, Warsaw, Indiana, USA).

The patient was placed in a right lateral decubitus position under epidural anesthesia. Two small incisions were made along the front edge of the left iliac crest, about 1 cm apart, and the two threaded pins were inserted into the thickest part of the iliac crest. Then, the pelvic attachment device was placed. After surgical exposure, the reference points for the acetabulum and femur were put through the Hardinge approach. Following confirmation of the limb length, the intramedullary nail was removed. The femoral neck was osteotomized, and the head of the femur was excised. Acetabular registration followed, marking thirty-two points inside the cavity and around its edge using a probe. Utilizing the robotic arm, the acetabulum was prepared with a 52mm reamer, and the cup placement was facilitated using an impactor (52mm, Triadent Hemispherical Stryker, Warsaw, Indiana, USA). The cup's position was assessed for inclination and anteversion (42° inclination and 18° anteversion) using the probe. Subsequently, the femoral canal was prepared, and the cemented femoral stem (Exeter size 2) was placed. A trial reduction with a +5mm 32mm-head exhibited satisfactory stability and leg length. The final femoral head of +5mm, 32mm Cocr V40 was placed. Subsequent measurements indicated that the surgically treated limb was 2mm shorter than the healthy one.

The patient experienced a satisfactory recovery. Due to the Hardinge approach, she exhibited a mild Trendelenburg gait, which improved over time. At the final follow-up, two years after the revision hip surgery, the patient resumed regular everyday activities, walked without assistance, and lived independently.

Discussion

The robotic arm-assisted hip surgery represents a paradigm shift in orthopedic procedures, offering distinct advantages rooted in precision and individualized planning.[6] this innovative system leverages advanced imaging technology to generate high-fidelity 3D models of a patient's anatomy derived from preoperative CT scans. These models facilitate meticulous preoperative planning, enabling surgeons to tailor surgical strategies to patients' unique anatomical nuances.[4,6] The resultant personalized approach allows for superior accuracy in implant placement, significantly reducing the margin for error compared to conventional methods.[7,8]

In the present report, we presented a revision hip surgery case where the system for accurate acetabulum component placement and the precise restoration of the hip joint anatomy and biomechanics was utilized. To our knowledge, this is the second case of hip revision surgery used by this system. Although the system has only been used for primary total hip arthroplasty, the indications could be expanded. Hip surgeries may soon be performed regularly with further advancements, especially in software revision.

In 2022, a revision hip arthroplasty case was reported in a patient with severe acetabular defect.[9] the robotic-assisted technology precisely executed the preoperative plan, ensuring the accurate placement of the acetabular component and augment at the intended position and angle. The robotic-assisted acetabular reaming was accomplished in a single pass, maintaining the integrity of the remaining acetabular bone mass exceptionally well without encountering any procedure-related complications.[9]

Identifying specific femoral and acetabular morphological characteristics is imperative to develop a customized plan. The robotic software provides crucial data points during the preoperative phase, encompassing the final size of prosthetic components, skeletal orientation, and the inclination and version of the acetabular cup and femoral stem.[10] These particulars require comparison with the opposite hip to address anatomical disparities.[10,11] In this case, we accurately measured the leg length difference and assessed the inclination and anteversion of the acetabulum, as depicted in [Figure 3]. The sizing for both the acetabulum cup and the femoral stem was also determined during the planning process.

Figure 3. Postoperative anteroposterior X-ray view

As reported in prospective studies, robotic arm-assisted hip arthroplasty outcomes showcase promising and favorable results in various aspects of patient recovery and surgical precision.[5,6,10] Studies have consistently demonstrated enhanced accuracy and precision in implant placement through the robotic arm-assisted system. The utilization of advanced imaging technology in preoperative planning has resulted in personalized surgical approaches tailored to individual patient anatomy. This has led to more accurate positioning of implants, potentially contributing to improved joint functionality and reduced risk of complications.[11-13]

Future expansions of robotic arm-assisted hip surgery converge on advancements in precision, expanded applications, incorporation of advanced technologies, and efforts to simplify integration and adoption. These forthcoming advancements can further elevate the standard of care in hip surgeries, fostering improved patient outcomes and expanding the horizons of orthopedic surgical innovation. This expansion encompasses exploring applications beyond primary total hip arthroplasty, potentially extending to revision surgeries and complex hip reconstructions.

Conclusion

Robotic arm-assisted hip arthroplasty ensures optimal implant position. This precise placement improves joint functionality and potentially mitigates the risk of postoperative complications, including implant-related issues and joint instability. As a result of this, we presented a hip revision case in which the robotic arm-assisted system was used. Future advancements in this technology may broaden its indications in complex reconstruction and revision cases.

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